

Anterior QRS forces in posterolateral infarction

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The QRS loop on the horizontal plane of the vectorcardiogram and the QRS complex in the right praecordial leads of the electrocardiogram were studied in 80 patients with strictly posterior and/or lateral infarction.

In all 30 patients with combined posterolateral infarction a ratio R/S greater than 1 in lead V₁ was found. In 19 out of the 23 patients with strictly posterior infarction and in all 9 patients with isolated lateral infarction this ratio was less than 1. Posteroinferior infarction (18 patients) behaved like strictly posterior infarction.

In posterolateral infarction a pronounced preponderance of the anterior over the posterior QRS loop forces was noted. The 0.02 sec vector was oriented anteriorly and to the right. In strictly posterior infarction the preponderance of the anterior over posterior QRS forces was not so great and the 0.02 sec vector was oriented to the left; the 0.04 sec and maximal QRS vectors were located anteriorly and to the left but in a more leftward orientation as compared to the corresponding vectors in posterolateral infarction. In isolated lateral infarction the 0.02 sec vector was always anteriorly and to the right, but the 0.04 sec and maximal QRS vectors were oriented posteriorly.

A possible mechanism of the appearance of the tall R wave in V₁ in posterolateral infarction is discussed.

Electrocardiographic diagnostic criteria of posterior myocardial infarction are inadequate. The posterior necrosis changes the orientation of the electrical forces anteriorly. In the praecordial leads V₄R and/or V₁ the ratio R/S is greater than or equal to 1 (Lipman and Massie, 1965). This ratio in lead V₁ is the main electrocardiographic feature of the posterior myocardial infarction (Massie and Walsh, 1960; Perloff, 1964; Hoffman *et al.*, 1965; Tandowsky, 1968).

Since, however, in posterior infarction the mean vector shifts anteriorly in the horizontal plane, maintaining the counterclockwise rotation, the vectorcardiogram offers diagnostic advantages (Hugenholtz, Forkner, and Levine, 1961; Gray *et al.*, 1972).

In a previous study in 10 patients with true posterior infarction we had noticed the frequent absence of the suggested typical electrocardiographic criteria (Toutouzas *et al.*, 1969). On the contrary, the vectorcardiogram showed a strictly posterior myocardial infarction in all the cases. Similar findings have been reported by Gray *et al.* (1972).

The above observations give rise to doubts concerning the diagnostic capabilities of the electro-

cardiogram in cases of true posterior myocardial infarction. Moreover, as is well known, a prominent R wave in V₁ has been described in cases of lateral (Pruitt, Dennis, and Kinard, 1963) as well as posterolateral infarction of the left ventricle (Levy *et al.*, 1950; Tulloch, 1952; World Health Organization, 1959).

In this study the influence of infarcts involving the posterior and the lateral wall of the left ventricle on the various segments of the vectorcardiographic QRS loop, as well as on the QRS complex of the right praecordial electrocardiographic leads, are investigated.

Subject and methods

Studies were made in 80 patients with myocardial infarction. Ten of these patients were admitted to the Cardiovascular Research Unit at Hammersmith Hospital and 70 to the Department of Cardiology of the University of Athens. Sixty-nine were men and 11 were women, 35 to 78 years of age (average 54 years).

The diagnosis of infarction was based on the clinical picture, the raised level of serum enzymes, the electrocardiogram, and the vectorcardiogram. The present observations were carried out 2 weeks to 3 years after the attack.

Cases with right or left bundle-branch block on the electrocardiogram as well as cases presenting clinical or

radiological evidence of right ventricular hypertrophy were excluded.

The patients were divided into 4 groups according to the vectorcardiographic and electrocardiographic location of the infarction.

Group I: Posterior infarction (23 patients).

Group II: Posteroinferior infarction (18 patients).

Group III: Posterolateral infarction with or without extension to the inferior wall (30 patients).

Group IV: Lateral or inferolateral infarction (9 patients).

The diagnosis of true posterior infarction was made by the vectorcardiogram alone. The following diagnostic criteria were applied.

a) Prominence of the anterior forces of the QRS loop, over the posterior ones, both in voltage and duration (Hugenholtz *et al.*, 1961; Gunnar *et al.*, 1967; Tandowsky, 1968).

b) Configuration and orientation changes of the second half of the QRS loop (Walsh *et al.*, 1962; Hoffman *et al.*, 1965).

c) Delay of the terminal QRS forces (Tranchesi *et al.*, 1961; Toutouzas *et al.*, 1969; Gunnar *et al.*, 1970).

The criteria for posteroinferior infarction were as follows.

a) The vectorcardiographic diagnostic criteria of posterior infarction.

b) Superior deviation of the 0.025 sec vector in association with a clockwise rotation of the initial QRS loop forces in the frontal plane (Massie and Walsh, 1960; Hugenholtz *et al.*, 1961).

c) Appearance of a Q wave in leads II and VF of the

electrocardiogram, with an amplitude at least 25 per cent that of the following R wave and duration equal to or longer than 0.04 sec (Myers and Oren, 1945; Goldberger, 1953; Friedberg, 1966).

Inferolateral infarction was diagnosed on the basis of the criteria used for the inferior wall infarction, plus the appearance of an abnormal Q wave in leads I, aVL, V₅, V₆, and/or a right orientation of the initial QRS loop forces ranged over 22 msec (Walsh *et al.*, 1962; Chou and Helm, 1967).

Vectorcardiograms were recorded on a Hewlett-Packard 1520A apparatus in 70 patients and on a Cambridge multichannel recorder in 10 patients using the Frank lead system (Frank, 1956).

Special attention was paid to the horizontal plane on which the following measurements of the QRS loop were made.

1) The orientation (in degrees) and the voltage (in mV) of the maximal vector of the QRS loop.

2) The orientation of the instantaneous vectors 0.02, 0.04, and 0.06 sec.

3) The duration (msec) of the right deviation of the initial forces of the QRS loop.

4) The duration of the anterior and posterior QRS forces and the maximal anterior and maximal posterior voltage of these forces.

5) The rotation of the QRS loop.

6) The delay in recording the terminal forces of the QRS loop.

The electrocardiograms taken on the same day as the vectorcardiograms comprised the 12 conventional leads and occasionally the precordial ones, V₄R and V₇. The ratio R/S in leads V₁ and V₂ was especially studied.

TABLE I Vectorcardiographic data derived from 80 patients: mean values and standard deviations (brackets)

Infarct groups	No. of patients	QRS loop in horizontal plane										Slow terminal forces (no. of patients)
		Rotation	Maximal vector		Vector orientation (degrees)			Anterior forces		Posterior forces		
			Orientation (degrees)	Voltage (mV)	0.02 sec	0.04 sec	0.06 sec	Duration (msec)	Maximum anterior voltage (mV)	Duration (msec)	Maximum posterior voltage (mV)	
I: Strictly posterior	23	CCW	+24.3 (15.3)	1.25 (0.5)	+62.3 (34)	+24.1 (18.5)	-105.3 (160)	45.5 (4.5)	0.50 (0.17)	35.5 (8.7)	0.33 (0.11)	19
II: Postero-inferior	18	CCW	+21 (15.8)	1.33 (0.36)	+60.1 (26.2)	+22.5 (9.7)	-79.4 (127)	46.5 (6.2)	0.58 (0.62)	35.2 (7.1)	0.39 (0.51)	11
III: Postero-infero-lateral or posterolateral	30	CCW	+49.4 (25.5)	1.09 (0.33)	+118.4 (20.2)	+39.3 (21.1)	-63.5 (110.3)	57.1 (9.8)	0.80 (0.27)	30.8 (8.3)	0.31 (0.25)	17
		CCW-CW										
IV: Lateral or infero-lateral	9	CCW	-41 (20)	1.3 (0.39)	+129 (32)	-48 (28)	-98.6 (33)	31.5 (7)	0.38 (0.10)	50.9 (6.2)	0.88 (0.26)	2
		CCW-CW										

CCW, counterclockwise; CCW-CW, counterclockwise - clockwise (figure-of-eight).

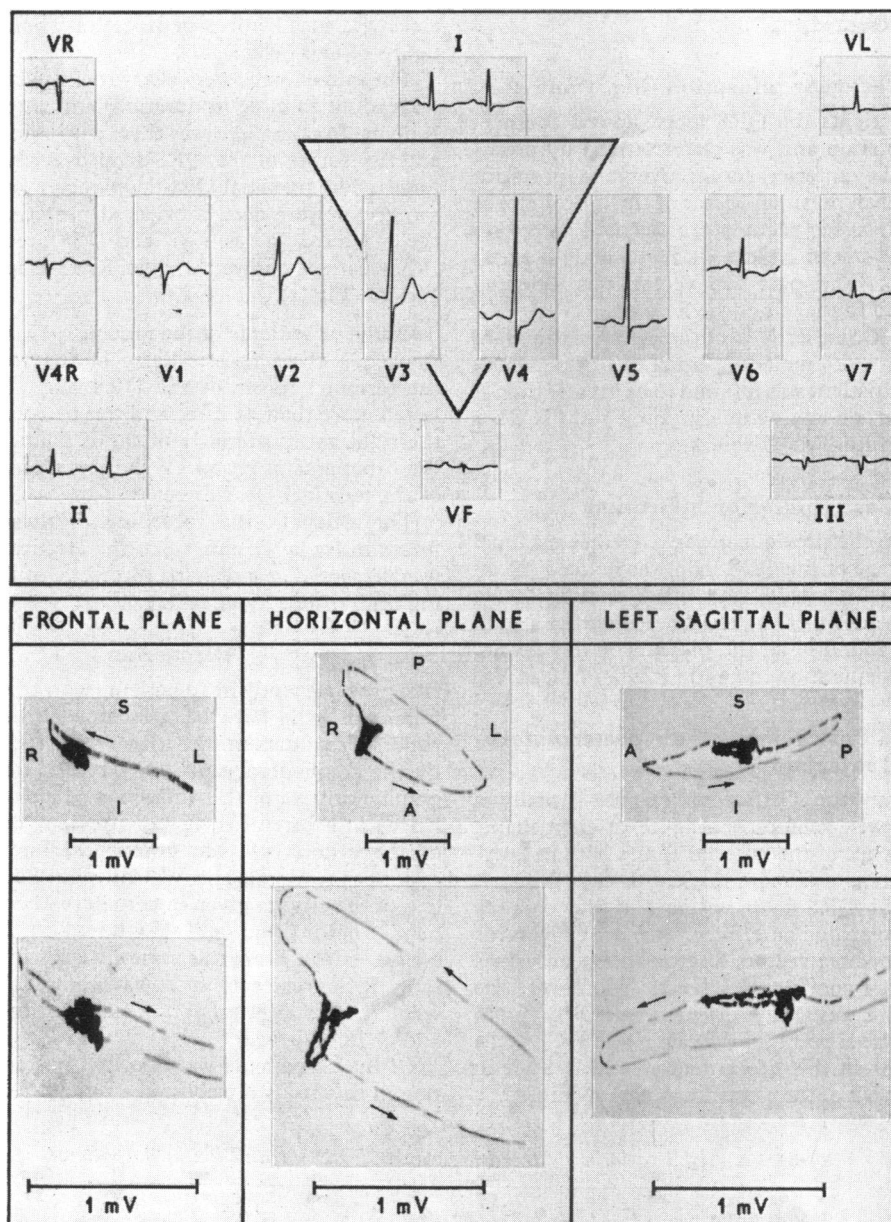


FIG. I Vectorcardiogram and electrocardiogram taken on the 15th day of acute myocardial infarction. There is anterior displacement of the QRS loop as seen in the horizontal and sagittal planes suggesting posterior infarction. The electrocardiographic changes are minimal; in V1 the R/S ratio is less than 1 (reproduced from Toutouzas et al. 1969, by permission of the authors and the publisher).

Results

The vectorcardiographic findings in the horizontal plane are presented in Table 1.

Group I: Posterior infarction (Fig. 1 and 2)

In all the patients the QRS loop showed counterclockwise rotation and was characterized by prominence of the anterior forces over the posterior ones. The mean maximal vector of the QRS loop, as well as the 0.04 sec vector were oriented anteriorly in all cases (mean values $+24.3^\circ$ and $+24.1^\circ$, respectively). The 0.02 sec vector was oriented anteriorly and to the left of the E point.

The ratio R/S in lead V₁ of the electrocardiogram was less than 1 (19 patients), equal to 1 (3 patients), and only in 1 patient was it found to be greater than 1. In 17 of the patients of this group a ratio R/S > 1 was found in lead V₂ (Table 2).

Group II: Posteroinferior infarction

Compared to the previous group a greater maximal anterior voltage of the QRS loop was noticed (mean value 0.58 mV), while the other findings were similar. In lead V₁ of the electrocardiogram a ratio R/S < 1 was found in all the patients of this group. Fourteen patients showed a ratio R/S > 1 in lead V₂.

Group III: Posterolateral or posteroinferolateral wall infarction

In this group the QRS loop showed usually a counterclockwise rotation or a figure-of-eight shape. The prominence of the anterior forces both in duration and voltage was more marked than in group I. The maximal QRS loop vector and the 0.04 sec vector were oriented anteriorly yet more rightwards than the respective vectors in group I (mean values $+49.4^\circ$ and $+39.3^\circ$, respectively). Moreover, the 0.02 sec vector was always oriented anteriorly and to the right of the E point (mean value $+118.4^\circ$).

All patients in this group had a ratio R/S > 1 in leads V₁ and V₂ of the electrocardiogram (Fig. 3).

Group IV: Lateral or inferolateral infarction

In this group the QRS loop rotation was counterclockwise in all but 2 patients, in whom it took a figure-of-eight shape.

The initial forces were always oriented to the right (exceeding 22 msec in duration) and anterior of the E point. In no patient was there a prominence of the anterior forces of the QRS loop over the posterior forces. The maximal QRS loop vector and the 0.04 sec vector were always oriented posteriorly and to the left (mean values -41° and -48° , respectively).

No patient showed a ratio R/S > 1 in leads V₁ and V₂ (Fig. 4).

Of the 71 patients of the groups I, II, and III, 47 showed a characteristic delay of the recording of the terminal forces of the QRS loop. This delay lasted more than 30 msec and was usually located to the right and posteriorly of the E point. Only 2 of the 9 patients of group IV showed analogous delay of the terminal QRS forces.

The delay in the recording of these terminal forces in leads V₁ and V₂ of the electrocardiogram was presented as a delayed recording of the ascending limb of the S deflection.

Discussion

In a previous study in 10 patients with true posterior infarction, who have been included in the present paper (Toutouzas *et al.*, 1969), we were impressed by the frequent absence of typical electrocardiographic criteria of this infarction. This observation led us to a careful review of previous descriptions of the criteria of true posterior infarction (Elek *et al.*, 1954; Massie and Walsh, 1960; Perloff, 1964) and of the criteria given in certain textbooks (Friedberg, 1966; Chou and Helm, 1967; Hurst and Logue, 1970). From this review we concluded that a ratio R/S greater than 1 was commonly present when the posterior infarction extended to the lateral and/or inferior wall.

Of the 23 patients with isolated posterior infarction in this study, 19 showed a ratio R/S less than 1

TABLE 2 R/S ratio in electrocardiographic leads V₁ and V₂ in 80 patients

Infarct groups	No. of patients	V ₁		V ₂	
		R/S \geq 1	R/S < 1	R/S > 1	R/S < 1
I: Strictly posterior	23	4	19	17	6
II: Posteroinferior	18	0	18	14	4
III: Posteroinferolateral or posterolateral	30	30	0	30	0
IV: Lateral or inferolateral	9	0	9	0	9

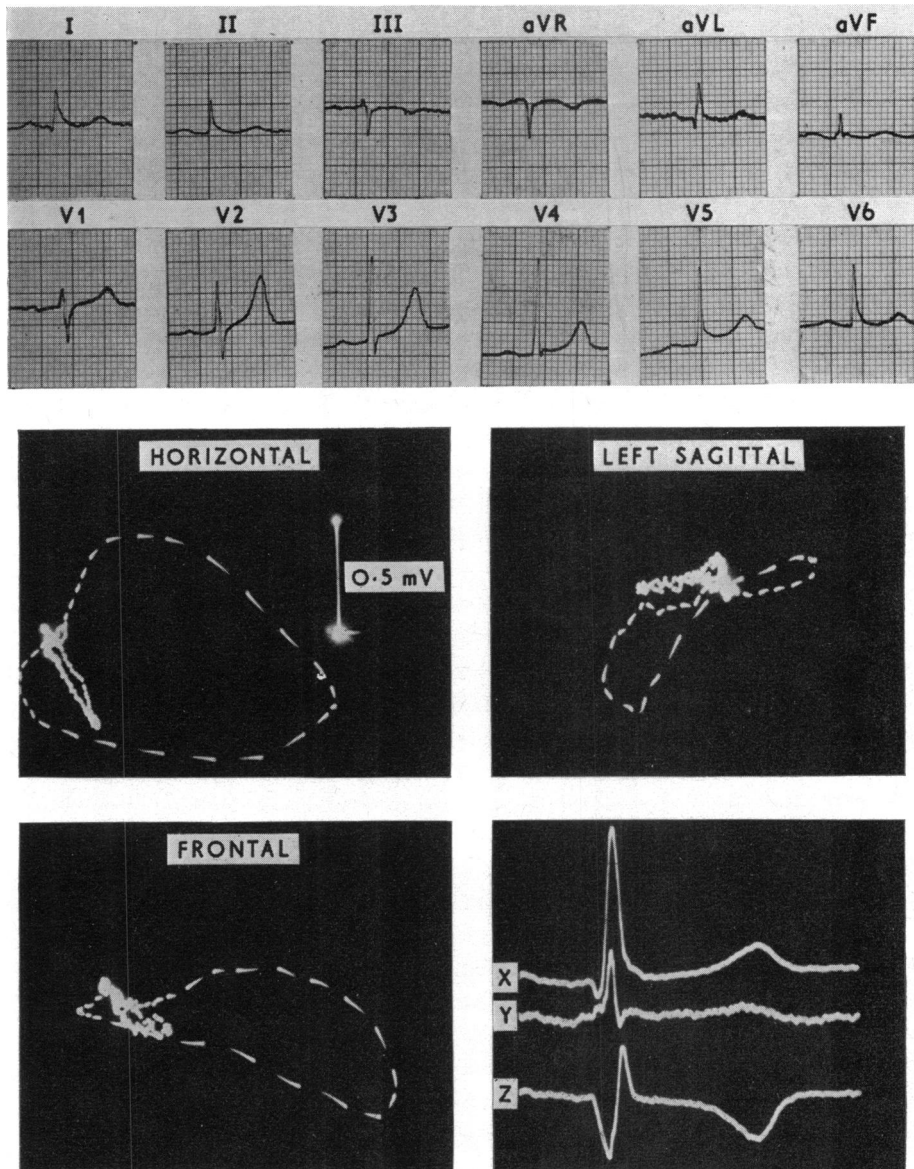


FIG. 2 Strictly posterior infarction. Ten days before the above electrocardiogram and vectorcardiogram were recorded, the patient, 49 years of age, presented the clinical picture of an acute infarction, followed by a rise in the serum enzymes. The vectorcardiogram as well as the Z axis of the orthogonal electrocardiogram show a preponderance of the anterior over the posterior QRS forces; the initial QRS forces directed to the right of the E point are normal. The electrocardiogram shows tall T waves in V1 to V3; however, the ratio R/S in V1 is less than 1.

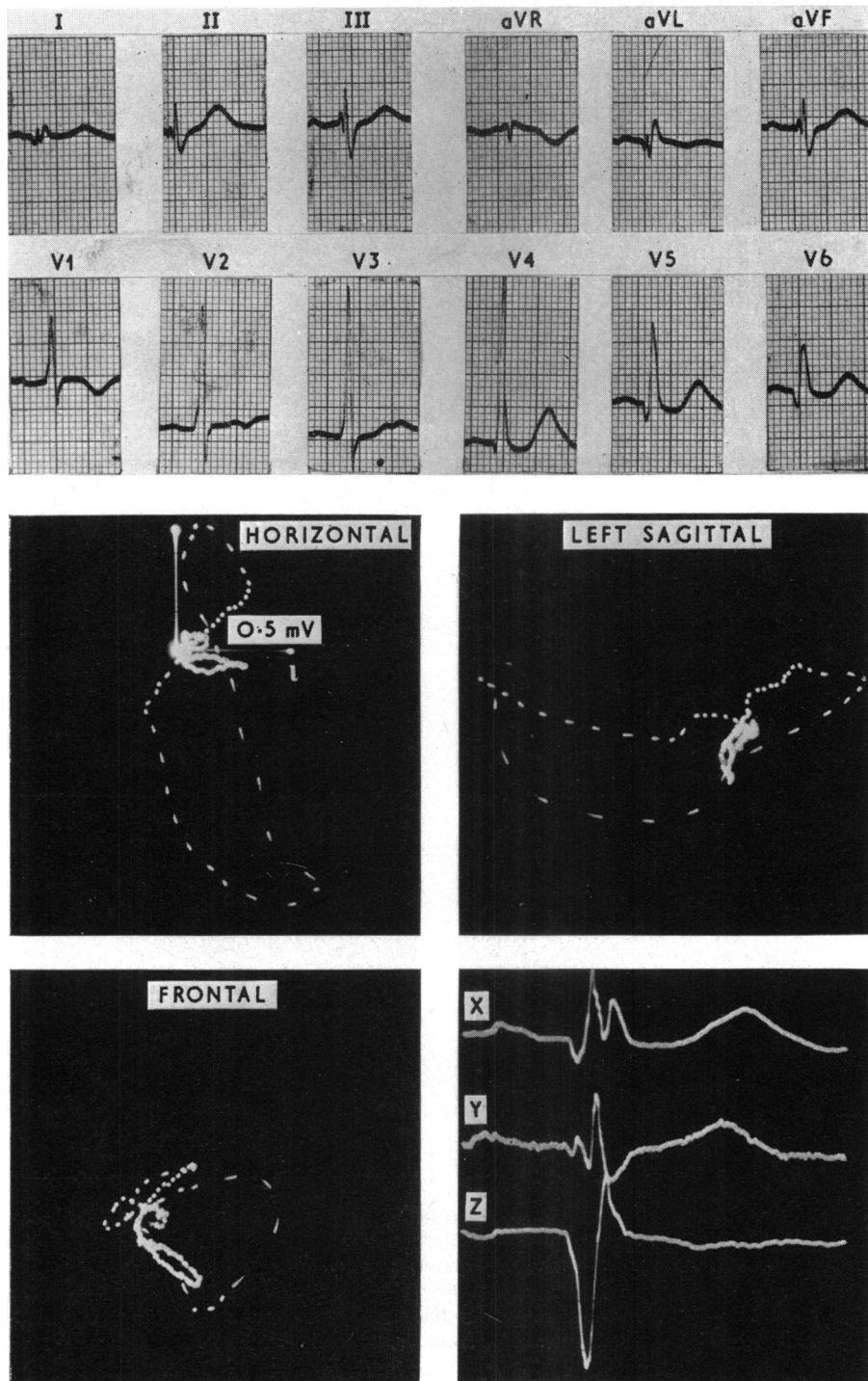


FIG. 3 Posterolateral infarction probably extended to the inferior wall. The vectorcardiogram and the Z axis of the orthogonal electrocardiogram show pronounced preponderance of the anterior over the posterior QRS forces, combined with an increase of the initial forces to the right of the E point. In lead V1 the ratio R/S is greater than 1.

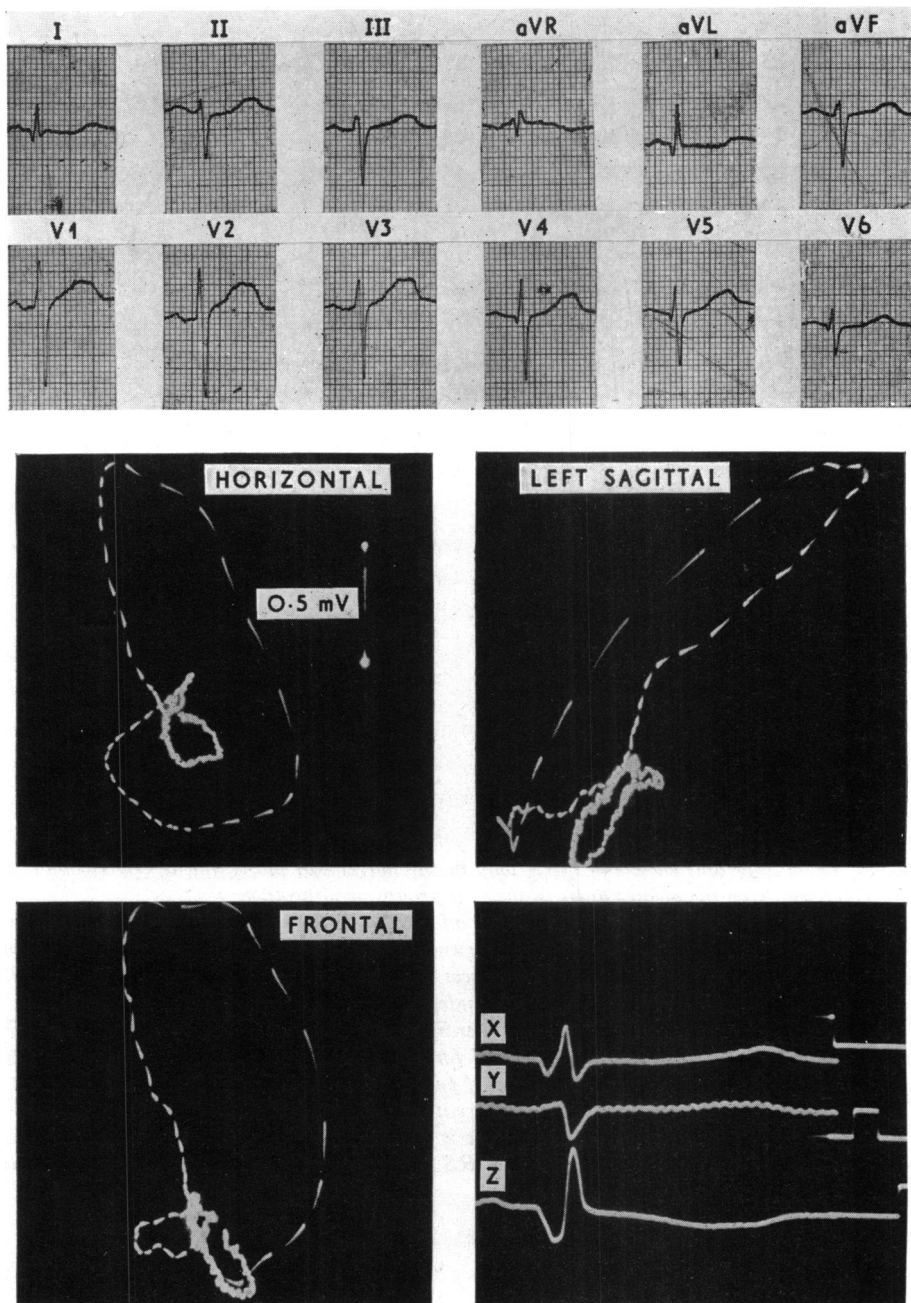


FIG. 4 Isolated lateral infarction. The initial QRS forces are oriented anteriorly and to the right of the E point in a range greater than 25 msec. The corresponding abnormality in the electrocardiogram is a Q wave in leads DI, aVL, and V6. However, the main QRS loop is oriented posteriorly and lead V1 shows a ratio R/S less than 1.

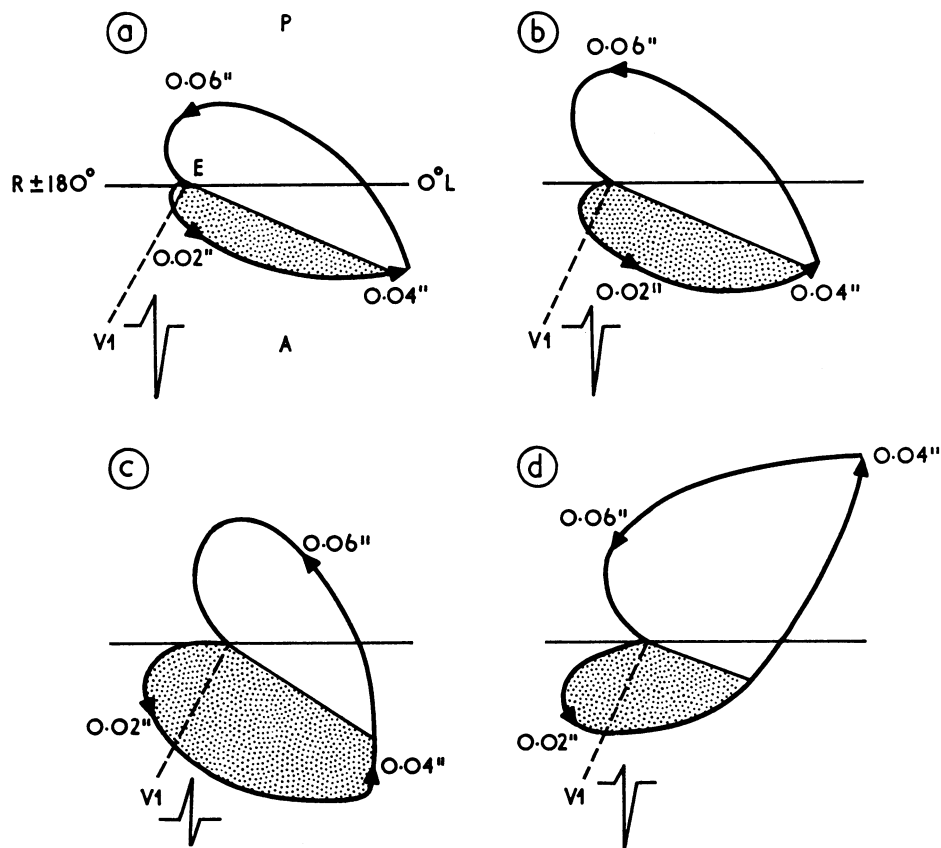


FIG. 5 These diagrams show the QRS loop in the horizontal plane and a QRS complex in lead V1 derived from the mean values in the four groups of infarction.

Strictly posterior (a) and posteroinferior (b) infarction. There is an obvious preponderance of the anterior over the posterior QRS forces. However, in lead V1 an R/S complex smaller than 1 is recorded because this lead 'sees' only the forces included in the shaded area, which is smaller than the remainder of the QRS loop which includes the negative forces for V1.

Posterolateral infarction (c). The preponderance of the anterior over the posterior QRS forces is pronounced. An increase of the initial forces to the right of the E point is also noted. These changes result in a greater shaded area of positive forces of the QRS loop than the rest of it; consequently lead V1 records an R/S ratio greater than 1.

Isolated lateral infarction (d). Though there is an increase of the initial forces anteriorly to the right of the E point the main body of the QRS loop is oriented posteriorly. Consequently lead V1 shows an R/S ratio less than 1.

in lead V1. This finding in part agrees with that of Massie and Walsh (1960) that the absence of a ratio R/S greater than 1 in V1 does not exclude the diagnosis of posterior infarction. Closer to our findings were those of Gray *et al.* who recently (1972), in a study of 31 patients with vectorcardiographic evidence of posterior infarction, found that only 6 had an electrocardiographic ratio R/S greater than 1 in V1. Moreover, the angiographic study of the left

ventricle and coronary arteries of the patients described by Gray *et al.* (1972) indicated coronary disease and/or asynergy of the posterobasal myocardial wall in 14 patients with a normal electrocardiogram.

The present study also shows that the ratio R/S in V1 is less than 1 in lateral or inferolateral infarction (group IV); it is greater than 1 in posterolateral infarction (group III). These results suggest

that the coexistence of posterior and lateral infarction produces the tall R wave in V₁.

In Fig. 5 a probable mechanism of the appearance of the tall R wave in V₁ after infarction is explained. In posterolateral infarction there is a loss of depolarization forces of the posterior and lateral wall of the left ventricle. Consequently, the QRS loop is displaced anteriorly and rightwards, i.e. in the direction of the praecordial lead V₁. Gray *et al.* (1972) agree that the tall R wave in V₁ is due to an orientation of the initial QRS forces anteriorly and to the right as it occurs in lateral infarction.

In our study the greatest displacement of the QRS loop anteriorly and to the right was found in the patients with posterolateral infarction (group III). In the horizontal plane the average vectors of 0.02 sec and 0.04 sec were oriented to +118° and +39°, respectively, and the maximal QRS vector to +49°. In addition, the mean values of the maximal anterior voltage and the duration of the anterior QRS forces were 0.80 mV and 57 msec, respectively, while the corresponding values of the posterior QRS forces were 0.31 mV and 30.8 msec. These values of group III were obviously different from those of the other three groups in which the anterior and rightwards displacement of the QRS loop was not pronounced.

Our findings suggest that the appearance of a tall R wave in V₁ after myocardial infarction could be explained by the occurrence of two essential changes in ventricular depolarization. Firstly, a pronounced preponderance of anterior over posterior QRS forces; secondly, a displacement of the initial QRS loop forces to the right of the E point exceeding 22 msec in duration. These changes occur in posterolateral infarction.

In true posterior or posteroinferior infarction the relatively small R wave in V₁ could be explained by a moderate preponderance of the anterior over the posterior QRS forces and a normal duration of the initial forces to the right of the E point. In addition, in lateral infarction without extension to the posterior wall, the ratio R/S in V₁ is less than 1 because the posterior QRS forces are greater than the anterior ones.

In most of the patients with posterior necrosis a delay of the terminal QRS loop forces is usually observed. This delay in the right praecordial leads appears as a slurring of the terminal 30–40 msec of the S deflection (Toutouzas *et al.*, 1969). This phenomenon may be evidence of intraventricular conduction disturbances, which are due to the presence of viable myocardial fibres around (First, Bayley, and Bedford, 1950) or within the infarcted area (Cabrera, Rocha, and Flores, 1959; Durrer, Van Lier, and Büller, 1964).

In conclusion, we believe that the diagnosis of isolated posterior infarction cannot be made solely on the basis of certain electrocardiographic criteria. Conversely, the diagnosis of this infarction can be arrived at in the majority of the patients by the vectorcardiogram. On the other hand, the appearance of a tall R wave or a ratio R/S greater than 1 in lead V₁ seems to be a more frequent finding in posterolateral infarction.

We wish to thank Professor J. P. Shillingford for allowing us to use data from 10 of his patients in this study.

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